Section 1000

LIFE CYCLE ANALYSIS - OVERVIEW

There is a need to make economically sound decisions concerning proposed expenditures. This is true in the design, construction, maintenance, and rehabilitation of pavements so that the most cost-effective alternative can be selected.

The time value of money and well recognized procedures are important considerations in the decision making process. A formal analysis using engineering economics is the answer.

Many techniques have been used over the years in selecting pavement design alternatives. In the past, most of the time we based our decisions strictly on first cost without consideration for future cost or pavement performance. For long-term investment in our pavements the initial cost may not be the most critical issue.

Life-cycle costs include all costs anticipated over the life (or analysis period) of the facility. The analysis requires identifying and evaluating the economic consequences of various alternatives over time. The highway which is cheapest is not the one which has cost the least money but the one which provides maximum service in proportion to the amount invested.

A valuable life-cycle costing study requires an organized approach. One approach consists of the following four steps:

1. Select the study area
2. Generate alternatives
3. Evaluate the designs
4. Select the design

There are several economic analysis methods that can be used for comparing alternatives. The discount cash-flow analysis methods (the annualized method, the present worth method, the rate-of-return method) are the methods most often used. DOT uses the annualized method for the majority of pavement designs. Benefit-cost ratio method, break-even analysis method, payback period method, and capitalized cost method, are used less often. Factors that will influence the analysis results include inflation, discount rate, and analysis period.

The suggested steps in the process of selecting the cost-effective design alternatives for new or rehabilitated pavements are:

1. Determine the site characteristics and other input data that may influence the design. If rehabilitation is planned, evaluate the condition of the existing pavement.

2. Identify various pavement management strategies that might be used.

3. Identify all feasible alternatives that might satisfy the needs for the project using PMS output. Value engineering should be used in the process of generating alternatives.

4. Remove from further consideration any items that are common among all alternatives.

5. Select that analysis period to be used.

6. Select a suitable discount rate. DOT (Value Engineering Section) re-evaluates the discount rate on a yearly basis and publishes the rate through the Standards Committee. For FY 95, we will be using a discount rate of 4%.

7. List the performance characteristics of the different alternatives being considered. Determine the time intervals for future maintenance and rehabilitation activities for each of the alternatives.

8. Make cost estimates for each alternative being considered. This includes the future costs for maintenance and rehabilitation. In urban areas include user-costs as appropriate.

9. Calculate annualized costs for the alternatives.

10. Make a sensitivity analysis on items or factors that may be subject to variation to ensure the selection of the proper alternative.

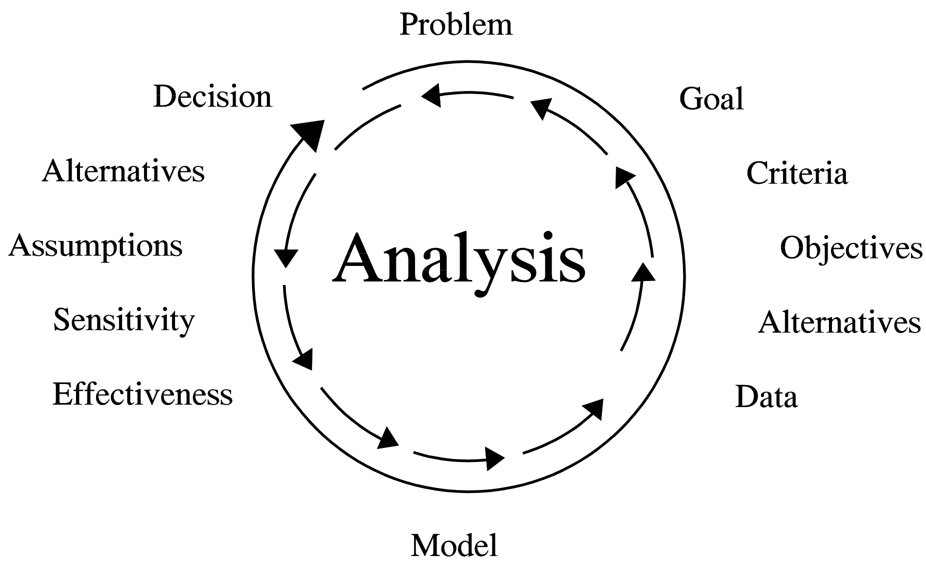
11. Evaluate the alternatives against other potentially overriding factors.

12. Select the most promising or preferred new pavement design or rehabilitation design based on all of the factors evaluated.

1000.01 Introduction

With increasing costs, decreasing budgets, and environmental impacts, effective decision-making provides the best choice. Getting to that point can be a problem. A systems approach provides the direction. Before getting started consider the following:

> An economic study must first answer the question: "Why do it at all?" In other words, does the proposed improvement represent an attractive investment when compared with other possible uses of available resources? Where there is only one plan for a particular improvement, a favorable answer clearly indicates that the project is desirable. However, where there are alternative methods for improvement, a second question is in order. It is "Why do it this way?" or "Which of the proposals is the best?" This is answered by finding whether the *increment* of investment between cheaper and more expensive plans also appears attractive. By successively eliminating those proposals that fail either the first or the second of these tests, the best of the lot may be found.[1]



Systems Analysis Diagram

In accomplishing the study, proper framework plays a leading role. No matter how good the data, incorrect procedures gives erroneous results. The following guidelines provide the proper direction.[2]

1. Economy studies are concerned with forecasting the future consequences of possible investments of resources. Past happenings, unless they affect the future, are not considered.

2. Each alternative among which choices are to be made must be fully and clearly spelled out.

3. The viewpoint taken in the analysis must be defined and observed.

Life cycle cost (LCC) analysis is the most appropriate economic evaluation process in deciding between alternatives. This analysis considers the cost of construction, rehabilitation, maintenance of a facility, and associated user impacts over a specific period, usually encompassing the service life of all alternatives. Two important definitions follow:

Life cycle costing—"Economic assessment of an item, area, system, or facility and competing design alternatives considering all significant costs of ownership over the economic life, expressed in terms of equivalent dollars"[3]

Life cycle design—"Analysis which considers the construction, operation, and maintenance of a facility during its entire design life."[4]

In general, life cycle costs include all costs anticipated over the life of the facility. As part of the analysis, trade-offs can be made among factors that may affect the life cycle cost of a pavement, such as the relationship between the initial costs of construction and the future cost of maintenance. The analysis requires identifying and evaluating the economic consequences of various alternatives over time or the life cycle of the alternative.[5]

Again, organization equals the key to success. This begins by selecting the study area followed by the Pavement Management System's generation of alternatives. Evaluating each alternative and make a selection decision.[5]

The process includes models based on the concepts associated with discounted cash flow analysis, wherein all the costs expected to occur throughout the life of the highway or bridge for example are estimated and converted to an equivalent uniform annual cost for purposes of comparison. Costs likely to occur during the life of the project should be considered in LCC analysis.[6] The costs are summarized over time by discounting all costs that occur at different times using the present worth method to account for the time value of money and can be shown as either total present worth or an annualized cost.

Costs normally associated with pavement reconstruction include:

1. Initial Construction Costs,
2. Maintenance Costs,
3. Rehabilitation Costs,
4. User Costs,
5. Salvage Value, and
6. Energy Costs.

No matter what the project, many costs would be the same for any specific project, therefore only differential costs require consideration for all project specific alternatives.

LCC analysis, the availability of funds, project specific and environmental conditions or constraints, project constructability, and the ability of each alternative to serve the anticipated volumes should all be used in the decision process for selecting the most appropriate alternative.

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3. Dell'Isola, A.J. and S.J. Kirk, *Life Cycle Costing for Design Professionals*, McGraw-Hill, New York, 1981.

4. Lindow, E.S., *Systems Approach to Life-Cycle Design of Pavements*, Vol I, *Life 2 Users Manual*, Report No. CERL-TR-M-253, Construction Engineering Research Laboratory, Dept of Army, 1978.

5. Peterson, Dale E., National Cooperative Highway Research Program Synthesis of Highway Practice No. 122: "Life-Cycle Cost Analysis of Pavements," Highway Research Board, National Research Council, Washington, D.C., 1985.

6. Veshosky, David and Nickerson, Robert L., "Life-cycle costs versus life-cycle performance," Better Roads Magazine, Vol. 63, No. 5, May 1993.